

Multiple Elevation Scan Option for SAILS (MESO-SAILS)

The Next Step in Dynamic Scanning
for the WSR-88D

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Operational Need

Faster Low-Level Updates

- ROC Operator survey results
 - Over 62% of respondents rate faster Volume Coverage Pattern (VCP) updates (more frequent low elevation updates) as the “Most Important VCP Improvement” the ROC could provide

Operational Need

Faster Low-Level Updates

Joplin Service Assessment (2011)

- **Finding #10:** ... “Limited scans at lowest elevation slices during this time impacted the WFO’s ability to ascertain the magnitude of the tornado.”
- **Recommendation #10:** “To enhance the ability to monitor rapid tornadogenesis and tornado intensification, NWS should develop and implement additional hybrid WSR-88D VCP strategies that allow for more continuous sampling near the surface (e.g., 1-minute lowest elevation sampling).”

Supplemental Adaptive Intra-Volume Low-Level Scan (SAILS) Review

- SAILS inserts one supplemental (lowest elevation defined in the VCP definition, normally 0.5°) split cut scan into the existing severe weather VCPs 12 and 212
- This new split cut scan is inserted into the “middle” of the volume scan to evenly space, as close as possible, the time intervals between low-level data updates
- The “middle” of the volume scan is adaptive and determined on a volume scan-to-volume scan basis based on the termination angle determined by AVSET
- SAILS will be deployed with Build 14 (Spring 2014)

Low-Level Scan Update Rates in Build 14

SAILS with AVSET

Elevation Angles (VCP 12)	VCP 12 Elevation Duration	Standard Termination Angle = 19.5	AVSET Termination Angle = 15.6	AVSET Termination Angle = 12.5	AVSET Termination Angle = 10.0	AVSET Termination Angle = 8.0	AVSET Termination Angle = 6.4
Duration	243 Sec	274 Sec	261 Sec	248 Sec	235 Sec	222 Sec	209 Sec
0.5 Elevation Update Times	253 Sec *	136 Sec and 148Sec *	136 Sec and 135 Sec *	122 Sec and 136 Sec *	122 Sec and 123 Sec *	108 Sec and 124 Sec *	108 Sec and 111 Sec *
		Avg 147 Sec	Avg 140 Sec	Avg 134 Sec	Avg 127 Sec	Avg 121 Sec	Avg 114 Sec
* 10 Seconds Added to Account for Retrace Time. Avg estimate includes 10 additional seconds to account for elevation transition time							

QUESTION?

Are More Frequent Low Level Scan
Updates Possible
with the WSR-88D?

The answer is:

YES

Multiple Elevation Scan Option for SAILS (MESO-SAILS)

- Building on SAILS, MESO-SAILS allows the operator to select either 1, 2 or 3 supplemental low-level scans (verses only 1 supplemental scan) per volume scan (for VCP 12 and VCP 212)
- These additional supplemental scans are evenly spaced, as close as possible in time, throughout the volume scan
- The new MESO-SAILS options will result in 2, 3 or 4 low-level elevation scan updates per volume scan, as per the operator's selection.

MESO-SAILS x2 with AVSET

Elevation Angles (VCP 12)	VCP 12 Elevation Duration	Term Angle 19.5	AVSET Term Angle 15.6	AVSET Term Angle 12.5	AVSET Term Angle 10.0	AVSET Term Angle 8.0	AVSET Term Angle 6.4
0.5°	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec
0.9°	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec
0.5°							31 Sec
1.3°	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec
0.5°		31 Sec	31 Sec	31 Sec	31 Sec	31 Sec	
1.8°	15 Sec	15 Sec	15 Sec	15 Sec	15 Sec	15 Sec	15 Sec
2.4°	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec
0.5°							31 Sec
3.1°	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec
0.5°						31 Sec	
4.0°	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec
0.5°				31 Sec	31 Sec		
5.1°	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec
0.5°			31 Sec				
6.4°	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec
0.5°		31 Sec					
8.0°	13 Sec	13 Sec	13 Sec	13 Sec	13 Sec	13 Sec	
10.0°	13 Sec	13 Sec	13 Sec	13 Sec	13 Sec		
12.5°	13 Sec	13 Sec	13 Sec	13 Sec			
15.6°	13 Sec	13 Sec	13 Sec				
19.5°	13 Sec	13 Sec					
Duration	245 Sec	305 Sec	292 Sec	279 Sec	266 Sec	253 Sec	240 Sec
0.5 Elevation Update Times	243 Sec	93 Sec, 116 Sec, and 106 Sec*	93 Sec, 102 Sec and 107 Sec*	93 Sec, 88 and 108 Sec*	93 Sec, 88 Sec and 95 Sec*	93 Sec, 74 Sec and 96 Sec*	62 Sec, 91 Sec and 97 Sec*
		Avg 108 Sec	Avg 104 Sec	Avg 100 Sec	Avg 96 Sec	Avg 90 Sec	Avg 84 Sec

* ~10 Seconds Added to Account for Retrace Time. Avg estimate includes 10 additional seconds to account for elevation transition time

MESO-SAILS x3 with AVSET

Elevation Angles (VCP 12)	VCP 12 Elevation Duration	Term Angle 19.5	AVSET Term Angle 15.6	AVSET Term Angle 12.5	AVSET Term Angle 10.0	AVSET Term Angle 8.0	AVSET Term Angle 6.4
0.5°	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec
0.9°	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec
0.5°				31 Sec	31 Sec	31 Sec	31 Sec
1.3°	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec
0.5°		31 Sec	31 Sec				31 Sec
1.8°	15 Sec	15 Sec	15 Sec	15 Sec	15 Sec	15 Sec	15 Sec
0.5°						31 Sec	
2.4°	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec
0.5°			31 Sec	31 Sec	31 Sec		
3.1°	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec
0.5°		31 Sec					31 Sec
4.0°	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec
0.5°						31 Sec	
5.1°	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec
0.5°				31 Sec	31 Sec		
6.4°	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec
0.5°			31 Sec				
8.0°	13 Sec	13 Sec	13 Sec	13 Sec	13 Sec	13 Sec	
0.5°		31 Sec					
10.0°	13 Sec	13 Sec	13 Sec	13 Sec	13 Sec		
12.5°	13 Sec	13 Sec	13 Sec	13 Sec			
15.6°	13 Sec	13 Sec	13 Sec				
19.5°	13 Sec	13 Sec					
Duration	243 Sec	336 Sec	323 Sec	310 Sec	297 Sec	284 Sec	271 Sec
0.5 Elevation Update Times	243 Sec	93 Sec, 74 Sec, 86 Sec and 93 Sec*	93 Sec, 60 Sec, 87 Sec and 93 Sec*	62 Sec, 91 Sec, 73 Sec and 94 Sec*	62 Sec, 91 Sec, 73 Sec and 81 Sec*	62 Sec, 77 Sec, 73 Sec and 82 Sec*	62 Sec, 62 Sec, 74 Sec and 83 Sec*
		Avg 89 Sec	Avg 86 Sec	Avg 83 Sec	Avg 79 Sec	Avg 76 Sec	Avg 73 Sec

* 10 Seconds Added to Account for Retrace Time.

Avg estimate includes 10 additional seconds to account for elevation transition time

MESO-SAILS Initial Testing

- On Jun 25 and 26, 2013, KOUN was used to execute hardcoded VCP definitions that added two and three additional low level scans
 - VCP definitions emulated automated execution of MESO-SAILS
- ROC maintenance specialist and engineer observed the pedestal assembly during these test events
- No abnormal sounds or pedestal/antenna motions were noted

MESO-SAILS Initial Testing (cont)

Antenna/Pedestal Assembly Performance Specifications:

Maximum Rotation Rate = 36° /second

Maximum Elevation Rate = 36° /second

Maximum Elevation Acceleration/Deceleration Rate = 36° /second/second

SAILS Test VCP (SAILSx3) Performance Characteristics:

- Rotation Rate:
 - Surveillance Rotation Rate = 21.149° /second (same as standard VCP 12)
 - Doppler Rotation Rate = 24.994° /second (same as standard VCP 12)
- Elevation Rate:
 - 1.4° to 0.5° Average transition time* = .9297 seconds; Rate = 0.968° /second
 - 0.5° to 1.9° Average transition time* = 1.020 seconds; Rate = 1.373° /second
 - 4.0° to 0.5° Average transition time* = 2.049 seconds; Rate = 1.708° /second
 - 0.5° to 5.1° Average transition time* = 1.710 seconds; Rate = 2.690° /second
 - 8.0° to 0.5° Average transition time* = 2.255 seconds; Rate = 3.326° /second
 - 0.5° to 10.0° Average transition time* = 3.402 seconds; Rate = 2.792° /second

MESO-SAILS Initial Testing (cont)

Acceleration Rate:

1.4° to 0.5°	2.78°/second/second (Deceleration Rate = 8.33°/second/second)
0.5° to 1.9°	3.59°/second/second (Deceleration Rate = 10.77°/second/second)
4.0° to 0.5°	2.22°/second/second (Deceleration Rate = 6.67°/second/second)
0.5° to 5.1°	4.20°/second/second (Deceleration Rate = 12.59°/second/second)
8.0° to 0.5°	3.93°/second/second (Deceleration Rate = 11.80°/second/second)
0.5° to 10.0°	2.19°/second/second (Deceleration Rate = 6.57°/second/second)

NOTE: The acceleration/deceleration rates were calculated based on the following assumptions:

Acceleration/Deceleration is constant

The antenna/pedestal assembly accelerates 75% of elevation transition time interval and decelerates 25% of the time interval. In other words, it accelerates to some maximum velocity for 75% of elevation transition time interval and decelerates the remainder of elevation transition time interval.

These acceleration/deceleration percentages (75% and 25%) were chosen to represent a worst case scenario (the calculated deceleration rates are more aggressive than expected operational rates) and are not actual operational percentages.

*Average transition time computed from 6 volume scans using acc1 tool for timing information

Comparison Information

KINX VCP 21 Performance Characteristics.

- Elevation Rate:
 - 4.3° to 6.0° Average transition time* = 1.230 seconds; Rate = 1.382°/second
 - 6.0° to 9.9° Average transition time* = 1.665 seconds; Rate = 2.343°/second
 - 9.9° to 14.6° Average transition time* = 2.132 seconds; Rate = 2.205°/second
 - 14.6° to 19.5° Average transition time* = 1.646 seconds; Rate = 2.976°/second
- Acceleration Rate:
 - 4.3° to 6.0° 3.00°/second/second (Deceleration Rate = 8.99°/second/second)
 - 6.0° to 9.9° 3.75°/second/second (Deceleration Rate = 11.25°/second/second)
 - 9.9° to 14.6° 2.76°/second/second (Deceleration Rate = 8.27°/second/second)
 - 14.6° to 19.5° 3.60°/second/second (Deceleration Rate = 10.79°/second/second)

NOTE: The acceleration/deceleration rates were calculated based on the following assumptions:

Acceleration/Deceleration is constant

The antenna/pedestal assembly accelerates 75% of elevation transition time interval and decelerates 25% of the time interval. In other words, it accelerates to some maximum velocity for 75% of elevation transition time interval and decelerates the remainder of elevation transition time interval.

These acceleration/deceleration percentages (75% and 25%) were chosen to represent a worst case scenario (the calculated deceleration rates are more aggressive than expected operational rates) and are not actual operational percentages.

*Average of 5 volume scans (July 17, 2013 0933-0956Z) computed using acc1 tool

MESO-SAILS Initial Testing Findings

- While executing the SAILSx3 VCP
 - Operational rotation speeds and elevation changes were well within operational parameters of the antenna/pedestal drive assembly system.
 - The antenna elevation transitions (maximum $<10^\circ$) required to execute the additional SAILSx3 elevations are well within the design and performance specifications of the antenna/pedestal assembly.
 - SAILSx3 will not cause any excessive wear and tear on the system.

MESO-SAILS Continued Testing

- Multiple Elevation Scan Option for SAILS (MESO-SAILS) software included as non-operational in RPG Build 14
- Continue to use KOUN to test MESO-SAILS and collect data
- Since MESO-SAILS in part of Build 14
 - Will execute on KCRI when other testing permits
 - Will use KCRI to collect bandwidth usage data

Low-Level Scan Update Rates with MESO-SAILS x3 and AVSET

Elevation Angles (VCP 12)	VCP 12 Elevation Duration	Term Angle 19.5	AVSET Term Angle 15.6	AVSET Term Angle 12.5	AVSET Term Angle 10.0	AVSET Term Angle 8.0	AVSET Term Angle 6.4
Duration	243 Sec	336 Sec	323 Sec	310 Sec	297 Sec	284 Sec	271 Sec
0.5 Elevation Update Times	253 Sec	93 Sec, 74 Sec, 86 Sec and 93 Sec*	93 Sec, 60 Sec, 87 Sec and 93 Sec*	62 Sec, 91 Sec, 73 Sec and 94 Sec*	62 Sec, 91 Sec, 73 Sec and 81 Sec*	62 Sec, 77 Sec, 73 Sec and 82 Sec*	62 Sec, 62 Sec, 74 Sec and 83 Sec*
		Avg 89 Sec	Avg 86 Sec	Avg 83 Sec	Avg 79 Sec	Avg 76 Sec	Avg 73 Sec

* 10 Seconds Added to Account for Retrace Time. Avg estimate includes 10 additional seconds to account for elevation transition time

Benefits of Dynamic Scanning

- AVSET, SAILS and MESO-SAILS
 - Provide significantly more low-levels updates per unit time

VCP 12	Number of 0.5° Base Product Updates per Hour	Volume Product Updates per Hour
Standard Operation	14	14
AVSET	14 - 19	14 - 19
SAILS	24	12
AVSET and SAILS	24 - 32	12 - 16
AVSET and MESO-SAILS	40 - 50	10 - 13

- Do not impact quality of base data estimates
- Radar performance still meets operational requirements and within system design specs

MESO-SAILS Future

- Continue to use KOUN to test MESO-SAILS and collect data
- Since MESO-SAILS is included in Build 14
 - Will execute on KCRI when other testing permits
 - Will use KCRI to collect bandwidth usage data
- Plan to have a Field Test after Build 15 deployment (late 2014)

Questions ???

BACKUP Slides

MESO Defined

- English Dictionary

Meso – (prefix): middle or intermediate

Comparing VCP 21 to VCP 12* (SAILSx3)

Data Update Times

VCP 21 versus VCP 12* Elevation Continuity Timing			
KINX – VCP 21		KOUN – VCP 12* (with SAILSx3)	
Elevation	Delta Time	Elevation	Delta Time
0.5° – 1.5°	1:04	0.5° – 0.9°	:32
1.5° – 2.5°	1:04	0.9° – 1.4°	:31
2.5° – 3.4°	:33	1.4° – 1.8°	1:02
3.4° – 4.3°	:32	1.8° – 2.4°	:14
4.3° – 6.0°	:33	2.4° – 3.1°	:14
6.0° – 9.9°	:26	3.1° – 4.0°	:47
9.9° – 14.6°	:26	4.0° – 5.1°	:13
14.6° – 19.5°	:27	5.1° – 6.4°	:14
		6.4° – 8.0°	:13
		8.0° – 10.0°	:48
		10.0° – 12.5°	:13
		12.5° – 15.6°	:13
		15.6° – 19.5°	:14
VCP Duration	5:36		5:46
Delta Times were calculated from the end of one surveillance collection scan to the end of the next surveillance collection scan.			

Comparing VCP 21 to VCP 12* (SAILSx3) Data Update Times

VCP 21 verses VCP 12* Elevation Continuity Timing		
VCP 21 (12) Elevation	KINX – VCP 21	KOUN – VCP 12* with SAILSx3
0.5° – 1.5° (1.4°)	1:04	1:04
0.5° – 2.5° (2.4°)	2:08	2:19
0.5° – 3.4° (3.2°)	2:42	2:34
0.5° – 4.3° (4.1°)	3:14	3:20
0.5° – 6.0° (6.5°)	3:47	3:47
0.5° – 9.9° (10.1°)	4:13	4:48
0.5° – 14.6° (12.5°)	4:39	5:02
0.5° – 19.5°	5:06	5:28
VCP Duration	5:36	5:46

Times were calculated from the end of one surveillance collection scan to the end of the target surveillance collection scan.

Comparing VCP 21 to VCP 12* (SAILSx3) Data Update Times

VCP 21 verses VCP 12* Elevation Continuity Timing			
VCP 21 (12) Elevation	KINX VCP 21	KOUN VCP 12* (with SAILSx3)	Delta (VCP12*-VCP21) Seconds
0.5° – 1.5° (1.4°)	1:04	1:04	0
0.5° – 2.5° (2.4°)	2:08	2:19	+ 11
0.5° – 3.4° (3.2°)	2:42	2:34	- 09
0.5° – 4.3° (4.1°)	3:14	3:20	+ 06
0.5° – 6.0° (6.5°)	3:47	3:47	0
0.5° – 9.9° (10.1°)	4:13	4:48	+ 35
0.5° – 14.6° (12.5°)	4:39	5:02	+ 23
0.5° – 19.5°	5:06	5:28	+ 22
VCP Duration	5:36	5:46	+ 10

Times were calculated from the end of one surveillance collection scan to the end of the target surveillance collection scan.

Comparing VCP 11 to VCP 12* (SAILSx3) Data Update Times

VCP 11 versus VCP 12* Elevation Continuity Timing			
KBNX – VCP 11		KOUN – VCP 12* (with SAILSx3)	
Elevation	Delta Time	Elevation	Delta Time
0.5° – 1.5°	:38	0.5° – 0.9°	:32
1.5° – 2.5°	:43	0.9° – 1.4°	:31
2.5° – 3.4°	:21	1.4° – 1.8°	1:02
3.4° – 4.3°	:21	1.8° – 2.4°	:14
4.3° – 5.3°	:22	2.4° – 3.1°	:14
5.3° – 6.2°	:21	3.1° – 4.0°	:47
6.2° – 7.5°	:15	4.0° – 5.1°	:13
7.5° – 8.7°	:15	5.1° – 6.4°	:14
8.7° – 10.0°	:15	6.4° – 8.0°	:13
10.0° – 12.0°	:15	8.0° – 10.0°	:48
12.0° – 14.0°	:15	10.0° – 12.5°	:13
14.0° – 16.7°	:15	12.5° – 15.6°	:13
16.7° – 19.5°	:15	15.6° – 19.5°	:14
VCP Duration	4:50		5:46
Delta Times were calculated from the end of one surveillance elevation to the end of the next surveillance elevation.			

Comparing VCP 11 to VCP 12* (SAILSx3)

VCP 11 versus VCP 12* Elevation Continuity Timing			
KBNX – VCP 11		KOUN – VCP 12* (with SAILSx3)	
Elevation	Cumulative Time (sec)	Elevation	Cumulative Time (sec)
0.5° – 1.5°	38	0.5° – 0.9°	32
1.5° – 2.5°	81	0.9° – 1.4°	63
2.5° – 3.4°	102	1.4° – 1.8°	125
3.4° – 4.3°	123	1.8° – 2.4°	139
4.3° – 5.3°	145	2.4° – 3.1°	153
5.3° – 6.2°	166	3.1° – 4.0°	200
6.2° – 7.5°	181	4.0° – 5.1°	213
7.5° – 8.7°	196	5.1° – 6.4°	227
8.7° – 10.0°	211	6.4° – 8.0°	240
10.0° – 12.0°	226	8.0° – 10.0°	288
12.0° – 14.0°	241	10.0° – 12.5°	301
14.0° – 16.7°	256	12.5° – 15.6°	314
16.7° – 19.5°	271	15.6° – 19.5°	328
VCP Duration	290		346

Delta Times were calculated from the end of one surveillance elevation to the end of the next surveillance elevation.

Comparing VCP 11 to VCP 12* (SAILSx3) Delta Update Times

VCP 11 versus VCP 12* Elevation Continuity Timing			
VCP 11 (12) Elevation Continuity Timing	KBYX VCP 11	KOUN VCP 12* with SAILSx3	Delta (VCP12*-VCP11) Seconds
0.5° – 1.5° (0.9°)	38	32	- 6
0.5° – 2.5° (1.4°)	81	63	-18
0.5° – 3.4° (1.8°)	102	125	+23
0.5° – 4.3° (2.4°)	123	139	+16
0.5° – 5.3° (3.1°)	145	153	+8
0.5° – 6.2° (4.0°)	166	200	+34
0.5° – 7.5° (5.1°)	181	213	+32
0.5° – 8.7° (6.4°)	196	227	+31
0.5° – 10.0° (8.0°)	211	240	+29
0.5° – 12.0° (10.0°)	226	288	+62
0.5° – 14.0° (12.5°)	241	301	+60
0.5° – 16.7° (15.6°)	256	314	+58
0.5° – 19.5°	271	328	+57

Times were calculated from the end of one surveillance elevation to the end of the target surveillance elevation.